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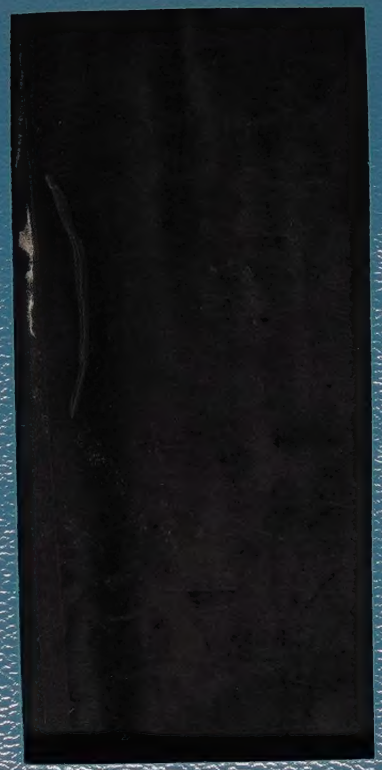

INSTRUCTION AND MAINTENANCE MANUAL

ITHACO MODEL 461

CHARGE AMPLIFIER

MANUAL PRINTED MAY, 1978

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MANUAL # 9

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SECTION 1

GENERAL DESCRIPTION

1.1 Description

The Model 461 is a compact, plug-in Charge Amplifier which uses a Model P17 Power Supply-Calibration Generator to provide power and calibration signals. Three of these amplifiers can be plugged into a portable carrying case (Model S21) for laboratory or field service, or up to seven can be plugged into a rack-mount (Model S11) for use in test instrumentation stands. The transducer sensitivity range switch and the transducer sensitivity dial will permit the amplifier to accommodate transducer sensitivities of 1 to 110 pC/g, psi, lb. The range switch, along with the transducer sensitivity switch, will permit full scale output from .03 to 3000 g, psi, lb. Full scale output voltage can be internally selected for 1, 1.414, 2.50 and 5.0V peak output for full scale input while maximum output current of 25 ma peak will drive most galvonometers.

1.2 Options

Options are factory modifications of a standard instrument that is requested by the customer. The following options are available and where necessary, detailed coverage of the option is included throughout the manual.

1.2.1 Option G

Galvonometer Output. Factory modification consists of adding a PC card containing a power amplifier suitable for driving long lines or galvonometers with a linear output of ±5 volts peak and ±85 ma peak with a current limit of 100 ma pk. A front panel screwdriver adjustment is added to permit the galvo output to be adjusted from 0.1 to 1.0 times the amplifier output. For further information refer to Section 2.3.2.

1.2.2 Option M

Meter. Factory modification consists of adding a detector card and front panel meter. The detector provides a signal proportional to the average value of the amplifier output. Whereas the meter responds to the average value of the input excitation, it is scaled to indicate, in conjunction with the range switch, the pk g, psi, lb for the input signal for sine waves. Refer to Section 2.3.3 for details.

1.2.3 Option S

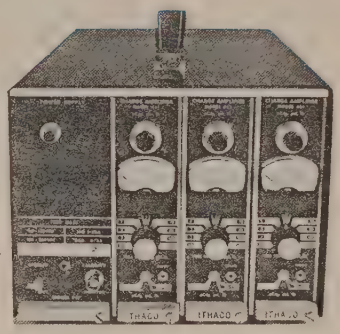
Servo Output. Factory modification consists of adding a module and a number of components to the amplifier PC board. The servo will provide outputs of 10 pk mv/pk g, psi, lb, regardless of range setting, for inputs of up to 300 g, psi, lb. This output can be used with the shaker servo while still permitting the amplifier range to be set for optimum recording of data.

MODEL 461
CHARGE AMPLIFIER

ITHACO
735 WEST CLINTON STREET ITHACA NEW YORK 14850 PHONE 607-272-7640 TWX 510-255-9307

Model 461 is an improved charge amplifier for use with piezoelectric accelerometers. This type of amplifier presents a virtual short circuit to the accelerometer, and provides a voltage output proportional to charge delivered by the accelerometer. Because of the very low input impedance -- over two microfarads -- amplifier accuracy is virtually unaffected by cable capacity loading the accelerometer.

A 10-turn dial on the front panel is calibrated for two ranges of transducer sensitivity, 1 to 11 and 10 to 110 picocoulombs per g, psi, lb. The range switch follows a 1-3-10 sequence from .03 to 3000 g, psi, lb full scale.



SIGNIFICANT FEATURES

- Very low intrinsic noise
- Usable bandwidth is 1 Hz to 100 kHz
- No transients induced by range switching
- Greatly reduced sensitivity to resistive loading of input
- Mountings include a 7 channel rackmount, and a 3 channel portable case
- Demountable preamp may be remotely operated for absolute minimum system noise
- Long "warm-up" time is not required--amplifiers operate to all specifications 30 seconds after turn-on
- Amplifiers will deliver an output of ±10 volts, permitting undistorted operation with crest factor as high as 10:1

ELECTRICAL SPECIFICATIONS

TRANSFER CHARACTERISTICS	Full scale output of 1, 1.4, 2.5 and 5 volt peak (internally selected) Transducer Sensitivity — Input for Full Scale Output 1 to 11 pC/g, psi, lb — 0.3 to 3000 g, psi, lb 10 to 110 pC/g, psi, lb — 0.03 to 300 g, psi, lb
MAXIMUM LINEAR INPUT	±10,000 pC on any range setting
STABILITY	±1% long term including temperature effects
LINEARITY AND DISTORTION	±1% worst case
ACCURACY	±1% midband, −1% maximum for 20,000 pf source capacitance
OVERLOAD RECOVERY	Immediate for momentary overloads to 10,000 pC
FREQUENCY RESPONSE	±5% 2 Hz to 50 kHz; ±12% 1 Hz to 100 kHz
NOISE (100 kHz Bandwidth)	.004 pC rms plus .002 pC rms for every 1000 pf of source capacitance; or 200 μV rms referred to output, whichever is larger
MAXIMUM LINEAR OUTPUT (less than 1% distortion)	±10 volts peak into 1k load ±1 volt peak into 100Ω load
OUTPUT CURRENT LIMIT	±25 mA typical (short circuit proof)
OUTPUT	15Ω maximum direct coupled, less than 10mV offset
CALIBRATION	1000 Hz sinewave, injected at input for full scale output
POWER SUPPLY	±15 volts at 50 mA each per channel
TEMPERATURE	−20°C to +55°C operating −55°C to +85°C storage

AMPLIFIER CONFIGURATION

SIZE	6.75" high, 2" wide panel, 10.5" deep
FUNCTIONS ON FRONT PANEL	
Range	10 position rotary switch, .03 to 3000 g, psi, lb. Coded for accelerometer sensitivity in 1–11 and 10–110 pC/g, psi, lb ranges
Sensitivity Dial	10-turn normalizing dial set by user to accelerometer sensitivity in pC/g, psi, lb
Sensitivity Range	Switch, 1–11 and 10–110 pC/g, psi, lb
FUNCTIONS ON AMPLIFIER REAR	
Input	BNC on demountable charge converter
Output	Rear panel BNC

MOUNTING CONFIGURATION

	MODEL S11	MODEL S21
USE	7 Channel Rackmount	3 Channel Portable Case
SIZE	7" high, 19" wide, 14" deep	7" high, 9.5" wide, 14" deep

MODEL P17 POWER SUPPLY AND CALIBRATION GENERATOR

The P17 Power Supply–Calibration Generator when operating with Model 461 Charge Amplifiers mounted in either a S11 Rackmount or S21 Portable Case, forms a calibration system. The internal plug-in 1 kHz cal oscillator is buffered to drive up to 1 V rms sinewave into 50 ohm cal line. The calibration for a full rack can be initiated by a front panel toggle switch. The power supply will provide all power requirements for seven 461 Charge Amplifiers.

MECHANICAL	6.75" high, 2.8" wide, 10.5" deep, plugs into extreme left slot of Models S11 and S21.

POWER SUPPLY

AC INPUT	105–130 VAC, 50–400 Hz standard; other voltage taps available
DC OUTPUT	±15 V @ 1 amp. (short circuit protected by 1.2 amp. current limit)

CALIBRATION GENERATOR

SIGNAL SOURCE (1V pk for full scale output)	1 kHz ±5% plug-in sinewave oscillator
LEVEL	0.707V to 1.000V rms (internally adjusted)
MONITOR	Front panel BNC (monitors calibration output)
CONTROL	CAL–OPERATE toggle switch calibrates up to seven 461 Charge Amplifiers

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SECTION 2

OPERATING INSTRUCTIONS

2.1 Unpacking and Inspection

2.1.1 Before shipment, this instrument was inspected and found free of electrical and mechanical defects. As soon as the instrument is unpacked inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is complete. If damaged in any way, a claim should be filed with the carrier and a copy forwarded to ITHACO. ITHACO will then advise you as to the disposition of the equipment and will arrange for repair or replacement without waiting for a settlement of a claim against the carrier.

2.1.2 Visual Inspection

A visual check should be made to confirm that there are no broken knobs or connections, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or broken.

2.1.3 Electrical Inspection

The instrument should be checked against its electrical specifications.

2.2 Installation Data

2.2.1 Model S11 Rackmount

The Model P17 Power Supply-Calibration Generator is plugged into the extreme left hand slot of the rackmount and 461 Charge Amplifiers are plugged into the remaining seven slots. The connections associated with each amplifier are located on the rear of the rackmount and are immediately behind the corresponding amplifier. The 7" high rackmount can be mounted in a standard 19" cabinet.

2.2.2 Model S21 Portable Case

The Model P17 Power Supply-Calibration Generator is plugged into the extreme left hand slot of the portable case and 461 Charge Amplifiers are plugged into the remaining three slots. The connectors associated with each amplifier are located on the rear of the case and are immediately behind the corresponding amplifier.

2.2.3 Amplifier Connections

Amphenol Blue Ribbon Connector - #26-4461 - 16p on amplifier
#26-4461 - 16s on rackmount

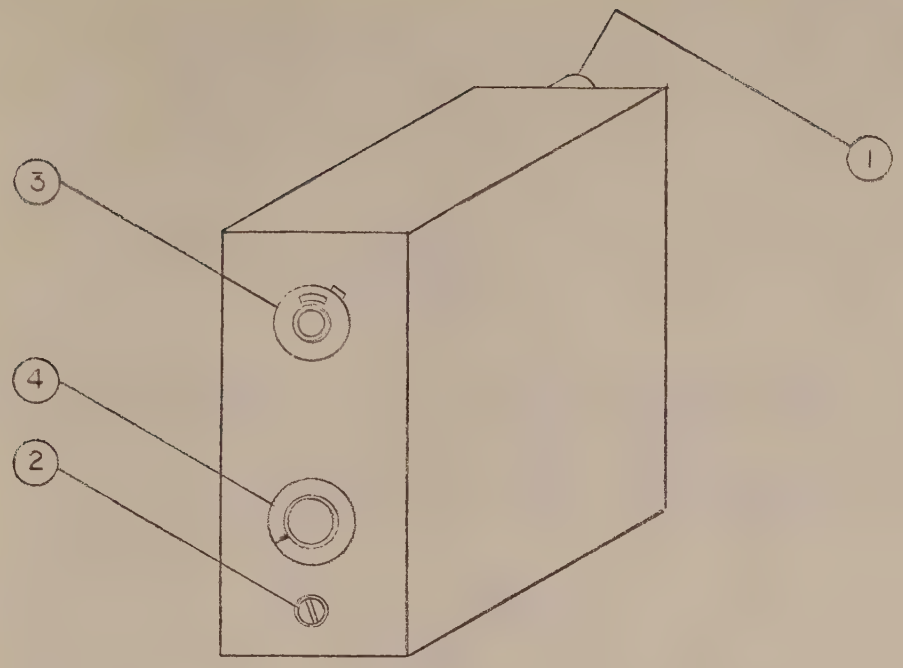
Pin #	Function
1	-15v .1% line and load regulation and less than 1 mv hum and noise
2	Signal and power ground
3	Cal Input
4	
5	Cal power return
6	Cal Power (-15v unreg)
7	Galvo output
8	Tape output
9	+15v .1% line and load regulation and less than 1 mv hum and noise
10	
11	
12	Servo Output (Option S)
13	Servo Ground (Option S)
14	
15	
16	Galvo output ground

Demountable Preamp

Input	BNC
Output	GK-9-32SL on amplifier

Rear connector used to mount Charge Preamplifier - Cannon GK-9-32SL (for extender cable GK-9-22C 1/2 mates with the post amp and GK-9-21C 1/2 mates with the charge preamplifier).

Pin #	Function
1	Output
2	Calibration Signal Input
3	+15 volts (decoupled)
4	-15 volts (decoupled)
5	Signal Ground
6	
7	
8	Signal Ground (connected at charge preamp only)
9	



2.3 Operation

2.3.1 1. Connect capacitive transducer to the input via low noise cable.

2. Set Transducer Sensitivity Range switch to the appropriate range for the transducer.

3. Set the Transducer Sensitivity dial to Transducer Sensitivity. For Transducer Sensitivity range 1-11 pC/g the dial reads directly. For Transducer Sensitivity range 10-110 pC/g the Transducer Sensitivity dial is multiplied by ten (lock the dial).

4. Set the Range switch to accommodate the maximum fullscale signal.

2.3.2 Galvonometer Output (Option G)

The typical galvonometer is a low impedance current operated device with a sensitivity expressed in units of deflection per unit of current. For operation of the galvonometer an external damping resistor is selected for fast response and limited overshoot,and is generally about 64% of critical damping. The galvonometer amplifier is a low impedance device, less than 1 ohm, thus the required damping can be connected directly to the galvonometer. Before setting the galvonometer adjustment of the 461, the peak voltage required at the galvo output must be ascertained:

		(Example)
a.	Galvo sensitivity, S	(.025"/ma)
b.	Galvo resistance, Rg	(24 ohms)
c.	Damping resistance, Rd	(26 ohms)
d.	Recorder fullscale deflection, D	(2")
e.	Galvonometer fullscale current, $I = \frac{D}{S}$	$(\frac{2"}{.025"/ma} = 80$ ma)
f.	Peak voltage required at galvo output, V ($V = I(Ra+Rg)$)	(.08)(24+26)=4.0 volts

In the example above, the galvonometer output must have 4.0 volts peak available, and to do so the tape output must have at least 4.0, inasmuch as the maximum galvo output is equal to the tape output. The fullscale tape output is internally selected via a jumper (See Figure 2.3.2) to give 5.0 v peak output and the amplifier gain recalibrated (See Section 2.3.5).

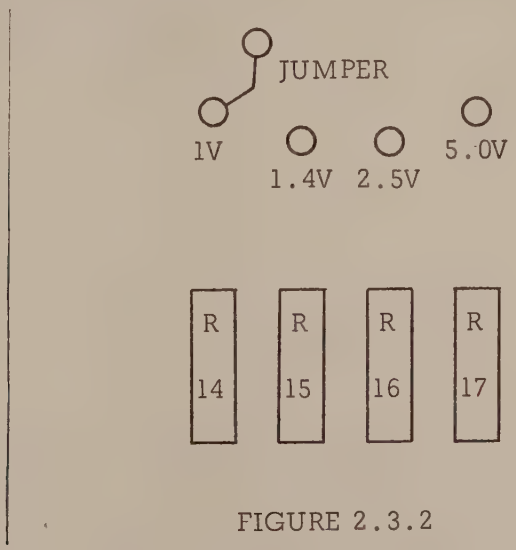


FIGURE 2.3.2

1. Select the galvo, damping resistor, etc., described above and select the appropriate fullscale output range (Recalibrate the amplifier gain if the jumper is changed).

2. Set the galvo adjustment to minimum (full counterclockwise).

3. Connect the galvo with appropriate series damping resistor to the galvo output.

4. Depress calibrate switch on the P17 to obtain a fullscale output signal.

5. Increase galvo adjust until fullscale operation is obtained on the recorder.

6. Fullscale deflection on the galvo recorder now corresponds to the input in engineering units indicated on the 461 Range Switch (for sinusoidal signals).

2.3.3 Meter (Option M)

A 1 1/2" taut-band meter is provided which, used in conjunction with the range switch, indicates the input signal directly in engineering units, g, psi, lb. The meter responds to the average value of the signal but is calibrated to read the peak for a sine wave, so that it acts directly as a vibration meter, reading in pk g's for sinusoidal acceleration signals. Signal level and available peak overload are thereby indicated.

The panel meter indicates the input signal directly peak engineering units for sinusoidal signals, but other types of signals require some conversion as indicated below:

TO CONVERT READING TO	USE THESE FACTORS
Peak value sinusoidal signal	read meter directly
Peak value random signal	not predictable
RMS value sinusoidal signal	.707X reading (meter 3 dB high)
RMS value random signal (Gaussian)	.803X reading (meter 1.95 dB high)
Average value sinusoidal signal	.636X reading (meter 3.95 dB high)
Average value random signal (Gaussian)	.636X reading (meter 3.95 dB high)

Inasmuch as the amplifier output overloads before any other portion of the 461 Charge Amplifier, and inasmuch as the panel meter monitors the amplifier output, the meter can be used to indicate the peak overload range available. The maximum peak output is 10 volts peak before clipping and the fullscale pk output is internally selected via a jumper for 1, 1.414, 2.5, and 5 V peak.

For Sinusoidal Signals:

Fullscale Range	Available peak overload for fullscale meter deflection	
1.0 V peak	X10	(20 dB)
1.414 V pk	X7.07	(17 dB)
2.50 V pk	X4	(12 dB)
5.0 V pk	X2	(6 dB)

For Random Gaussian Signals:

Fullscale Range	Available rms overload for fullscale meter deflection	
1.0 V pk	X12.5	(22 dB)
1.414 V pk	X8.85	(19 dB)
2.50 V pk	X5.0	(14 dB)
5.0 V pk	X2.5	(8 dB)

2.3.4 Servo Output (Option S)

The Servo Output is independent of the Range Switch and is a normalized output of 10 pk mv/pk g which is dependent only on the transducer sensitivity controls. Inasmuch as transducer sensitivity controls are the same for the 461 Charge Amplifier and the Servo Output, the tape output or galvonometer output can be set as necessary without concern for the servo output. Two applications where the servo output can be used is part of a frequency sweep vibration test or in association with a vibration meter.

Frequency Sweep Vibration Test

During a frequency sweep vibration test a sweep frequency oscillator drives a vibration exciter while slowly varying the frequency. Owing to resonances in the test specimen or vibration exciter, the power necessary to maintain the test specimen at a constant vibration level is not, however, constant with frequency. To keep the vibration level constant the output of the vibration pickup, usually an accelerometer, either built into the shaker or mounted on it, is fedback to the sweep oscillator to control the power into the shaker. This control, frequently called a compressor, usually requires 10 pk mv/pk g, input.

Vibration Meter

A Vibration Meter requires a pickup transducer and preamplifier, usually a piezoelectric accelerometer and charge preamplifier, which converts the input g level to a normalized 10 pk mv/pk g. The vibration meter itself consists of a variable gain amplifier with meter detector and meter with suitable ranges reading directly in g's. Inasmuch as the first step in the 461 Charge Preamp is to convert the charge to voltage and normalize it for transducer sensitivity, and inasmuch as the servo output is independent of range switching, the servo output can be used directly with vibration meter requiring 10 pk mv/pk g while still permitting the range switch to be set for optimum recording.

2.3.5 Calibration

Calibration circuitry for the 461 is shown in Figure 2.3.5. Shunt calibration is employed, which permits accurate calibration regardless of the capacity of the transducer, but inasmuch as the calibration signal (100 pc peak) is added to the input signal during calibration, the signal input must be lower than the cal signal.

Calibration circuitry for a 461 Charge Amplifier system including 461's, P17 and either a S11 or S21 is shown in Figure 2.3.5. The Model P17 Calibration-Generator supplies a 1V peak (.707V rms) sine wave to the cal input of each amplifier. This is accomplished by placing the OPER-CAL switch of the P17 to CAL. The calibration monitor BNC permits the operator to monitor the cal voltage. The cal voltage is factory set to 0.707 volts rms.

NOTE: The most likely source of error with shunt calibration is that the input signal is added to the cal signal, so that the calibration should be done with low input signals (preferably less than 1 pc peak).

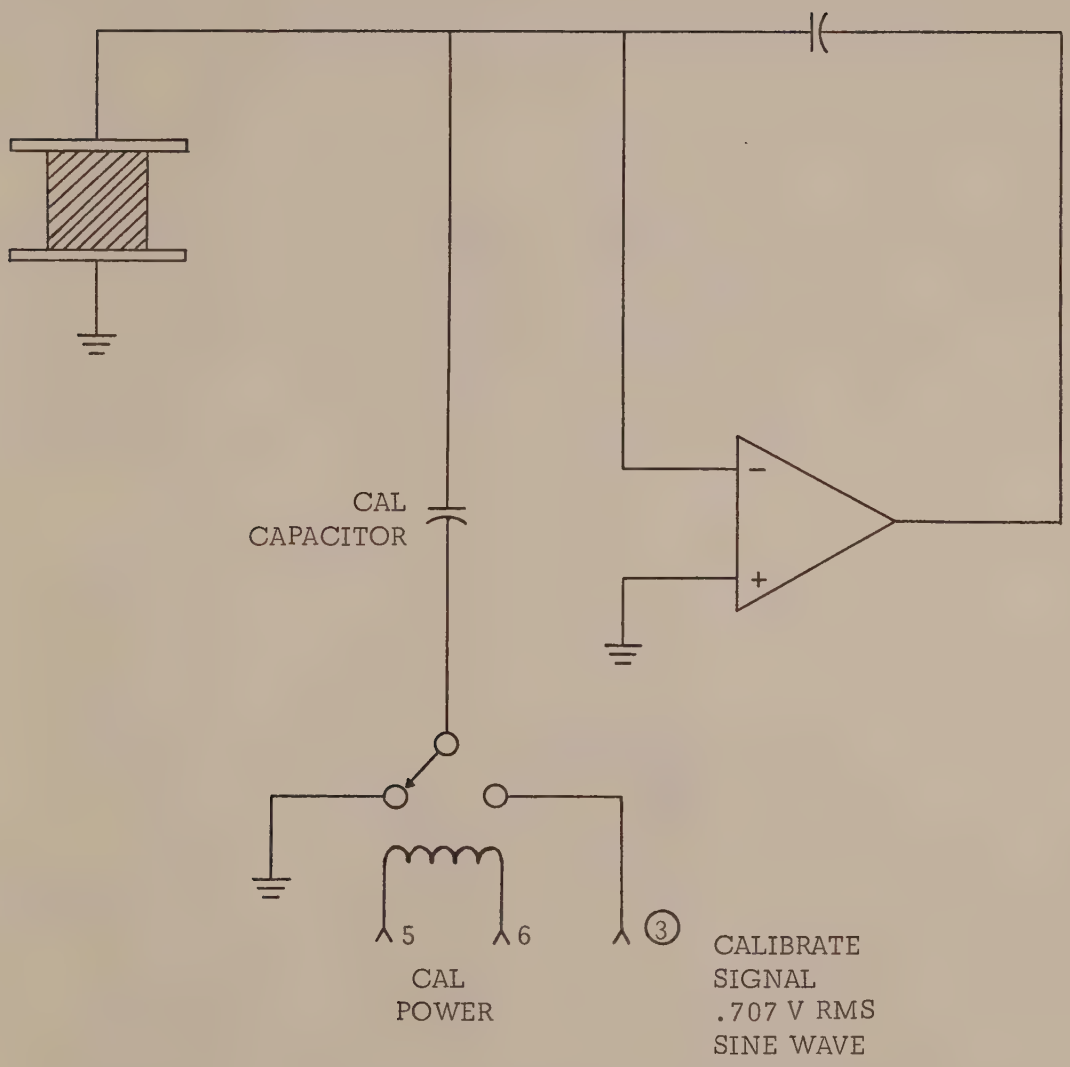


FIGURE 2.3.5.1 Simplified Schematic of Shunt Cal Circuit

SECTION 3

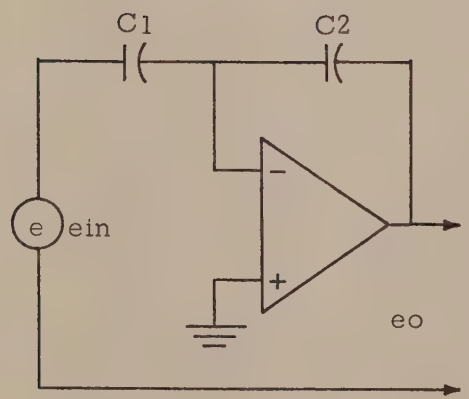
THEORY OF OPERATION

3.1 Introduction

The Model 461 Charge Amplifier System consists of a demountable Charge Preamplifier, a Charge Post Amplifier, either a S11 Rackmount for mounting in test stands or a S21 Portable Case for lab use and a P17 Power Supply-Calibration Generator which provides power and calibration signals.

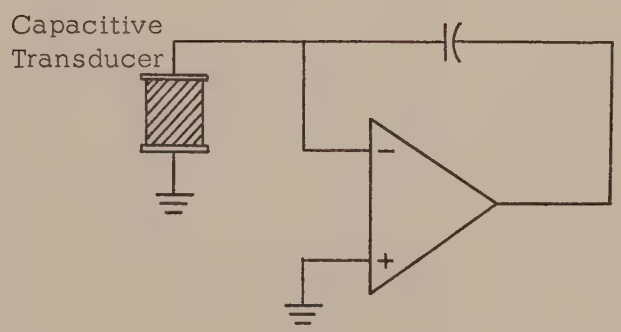
3.2 Charge Preamplifier

The Charge Preamplifier is potted and therefore the circuitry is not accessable for repair. The operation of the Charge Preamplifier is, however, identical to that of an operational amplifier with both input and feedback capacities (Figure 3.2.1). The transfer function of this stage would be $\frac{Co}{Cin} = \frac{C1}{C2}$. A transducer can be considered a voltage source in series with a capacitor, so the preamplifier gain = $\frac{C1}{C^2}$ where C1 is the capacitance of the transducer and the feedback capacitor C^2 is 1000 pf. Atlernately the transducer can be considered as a charge generator and the gain of the charge preamplifier is 1 mv/pc of charge (Figure 3.2.2).



$\frac{eo}{ein} = \frac{C1}{C2}$

FIGURE 3.2.1



eo = q/C2
eo = 1mv/PICOCOULMB
for 461

FIGURE 3.2.2

3.3 461 Post Amplifier

3.3.1 General

Referring to the charge amplifier Elementary Diagram in the rear of the manual, note that the 461 Post Amplifier consists of a variable gain input stage A1 normalizing amplifier, A2 (normalizes the amplifier for transducer sensitivities), a variable gain stage A3, a low pass filter (R23, L1, C9) for high frequency rolloff, an output attenuator switched by the range switch (R1, R2, R3, R4), and an output stage A4 with provision to change gain. Before discussing the stage in detail, consider the overall amplifier gain as a function of range setting. Assuming that the transducer sensitivity dial is set for 1.0 pC/g on the 1-11 pC/g range or 10 pC/g on the 10-110 pC/g range and the fullscale output is set for 1 V peak, then chart 3.3.1 gives the overall post amplifier gain and individual stage and attenuator gain. Any of the attenuators will be "on" when +15 volts is applied, and "off" when -15 volts is applied.

Each of the stages are discussed below as well as the available options.

RANGE	A1 STAGE	A2 STAGE	A3 STAGE		A4 STAGE		461
Fullscale	Gain	dial @1.00	Attenuator	Gain	Attenuator	Amplifier	Post Amp
g,psi,lb	dB	Gain, dB	dB	dB	Gain	Gain	Gain
300/3000	-30	+30	-30	0	.1	3.33	.333
100/1000	-30	+30	-30	0	.3	3.33	1.000
30/300	-20	+30	-30	0	.316	3.33	3.33
10/100	-10	+30	-30	0	.3	3.33	10
3/30	0	+30	-30	0	.316	3.33	33.3
1/10	0	+30	-20	+10	.3	3.33	100
.3/3	0	+30	-10	+20	.316	3.33	333
.1/1	0	+30	0	+30	.3	3.33	1000
.03/3	0	+30	0	+30	1.0	3.33	3333
CAL	-10		-30	0	.3	3.33	10

TABLE 3.3.1 GAIN CHART 461 POST AMPLIFIER
(Transducer Sensitivity Dial at 1.00 & Fullscale Output at 1 volt peak)

3.3.2 Input Stage

The input stage consists of an input attenuator with four attenuator positions, 0, -10, -20 and -30 dB followed by a unity gain amplifier suitable to drive the transducer sensitivity potentiometer. The attenuator switches are electrically controlled so that +15 volts will turn them on and -15 volts will turn them off. R1, R2, R3 and R4 will return the switch to -15 volts when the range switch is open.

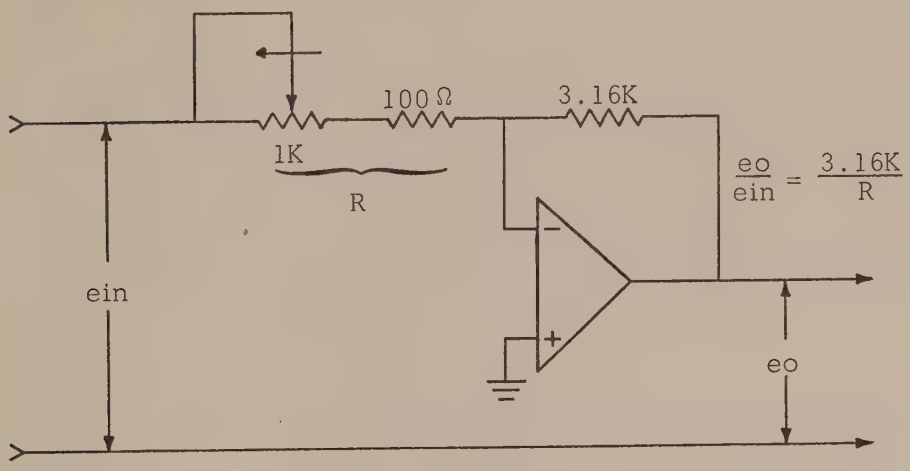


FIGURE 3.3.2 Simplified Diagram at the Transducer Normalizing Stage

3.3.3 Transducer Normalizing Stage

The transducer normalizer consists of an inverting amplifier which operates like an operational amplifier. Referring to Figure 3.3.2, the amplifier gain is equal to $\frac{3.16K}{R}$. At one extreme of the pot (dial set at 1.00) the resistance is 100 ohms and the gain is 31.6 (30 dB). At the other end of the pot (dial set at 10.0) the resistance is 1000 ohms and the gain is 3.16 (-10 dB). The gain of the stage is inversely proportional to the transducer sensitivity. Inasmuch as the potentiometers are not precisely 1000 ohms but are linear, the resistor in series with the pot should be precisely 1/10 the transducer potentiometer. This is accomplished by R11, R12 and R30.

3.3.4 30 dB Att/Amp

The 30 dB Att/Amp consists of a four position, electrically controlled attenuator (0, -10, -20 and -30 dB), followed by a 30 dB amplifier. Four input lines control the attenuator, each input will turn "on" the switch when +15 volts is applied and each switch will turn "off" when -15 volts is applied. R16, R17, R18 and R19 are used to pull the lines to -15 volts when the lines are open.

3.3.5 Output Stage

For purposes of discussion, output stage can be considered to consist of three sections (see Figure 3.3.5): a low pass filter for high frequency rolloff, an output attenuator controlled by the front panel switch, and an output amplifier with provisions for changing its gain.

The high frequency rolloff of the 461 is accomplished by R23, L1 and C9. It is a 2 pole low pass filter with a maximal flat or Butterworth characteristic.

The output attenuator has four attenuators: 1, .316, .3 and .1. The use of 10 dB steps in the preceeding stages require some gain correction to agree with the front panel range switch. Referring to chart 3.3.1, the range switch selects the necessary attenuation to give the appropriate gain. The output of the switch, S1C, is fedthrough Q2 when the charge amplifier is operating (Q2 is turned on by applying +15v at R20). When in calibration Q2 is turned off (R20 is returned to -15 volts) and Q1 is turned on (R21 is returned to +15 volts) so that an attenuation of .3 is selected during calibration.

The output amplifier is a non-inverting amplifier with a high input impedance. The gain is set by the feedback network. Jumping R24 to ground will provide 1 V peak output. Jumping R23, R26 or R27 to ground will provide 1.414, 2.5 or 5 V peak output respectively. R7, R8, R9 and R10 provide a means of adjusting the output offset to zero. R29 is the overall amplifier gain adjustment.

3.3.6 Power Isolation and Protection Circuitry

Diodes CR6 and CR8 protect the amplifier from reversal of the input power. Diodes CR5 and CR7 protect the amplifier when one of the power supplies is lost. Capacitors C19 and C18 are local bypasses on the power supplies.

The power isolation stage, A6 along with C12 through C17, provides additional filtering of the power lines necessary for the input and first stage.

3.3.7 Galvo Option (Option G)

When the galvo option is included, a front panel galvo adjust is provided, R2 which serves as an attenuator on the output of the 461. This signal is used to drive the unity gain galvo driver. Provisions are made for fine adjustment of current gain limits.

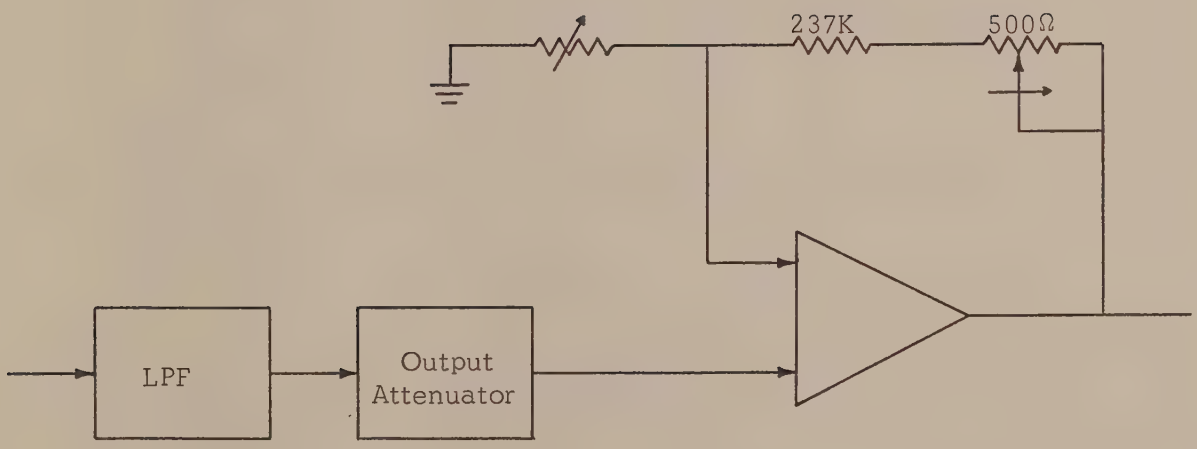


FIGURE 3.3.5 Block Diagram of Output Stage

3.3.8 Meter Option (Option M)

The inclusion of the Meter option consists of a front panel meter and the detector board (see Option M Assembly). The meter amplifier monitors the input of the output amplifier and is therefore unaffected by changes in the gain of the output amplifier. This signal is amplified, detected and averaged.

Referring to the Elementary Diagram for Option M and Figure 3.3.8, the input of the meter detector is a unity gain FET input buffer consisting of Q1 and Q6. This stage is followed by IC-1, which is an inverting half wave detector with a gain of 10. The inverted half wave signal, weighted and added with the input signal, results in a full wave signal at the output of IC2. C7 provides the smoothing. The smoothed dc output is applied to the meter via R20 and R21, and R21 is used to set the overall gain of the meter detector.

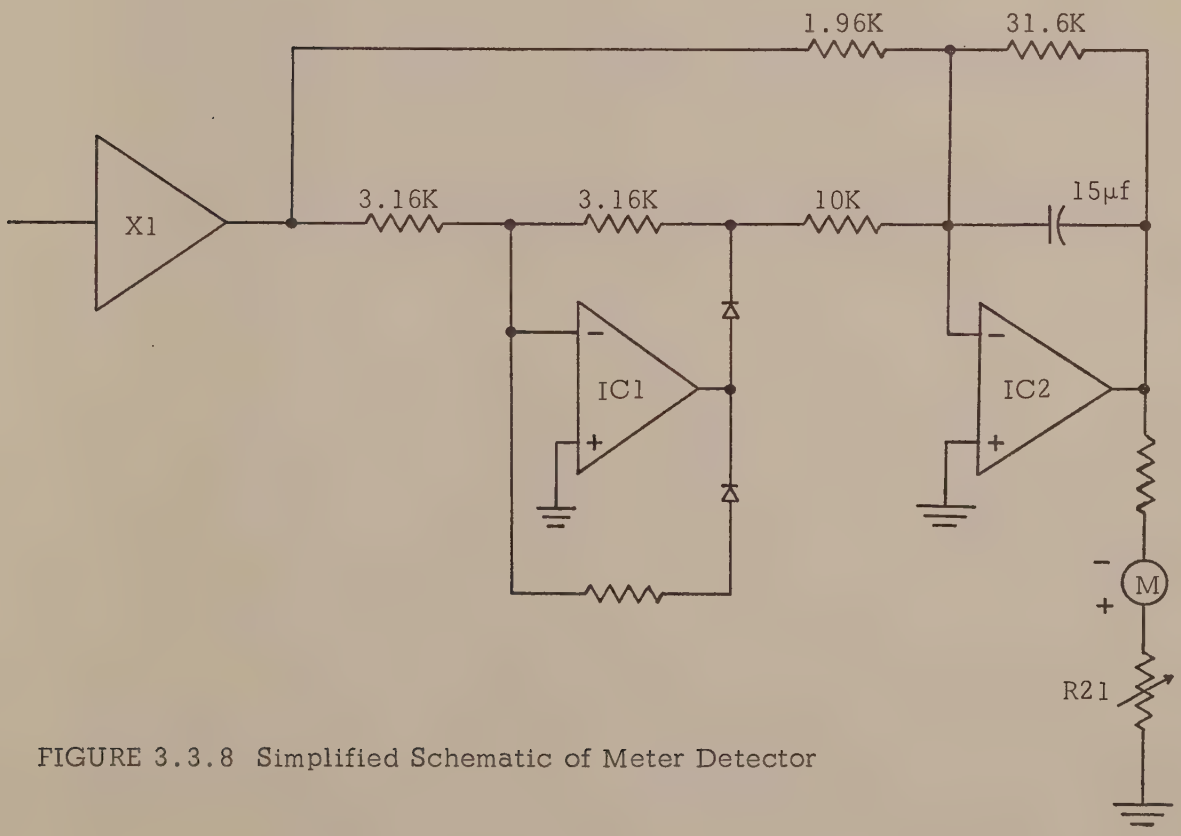


FIGURE 3.3.8 Simplified Schematic of Meter Detector

3.3.9 Servo Option (Option S)

The inclusion of the Servo Output will consist of adding the servo stage, A5, and the associated components on the motherboard (R13, R14, R15, C3, C4, C5, R31 and R32).

The Servo output is to provide 10 mv/g regardless of the range switch setting and transducer sensitivity. Therefore, the output must be taken after the transducer normalizing stage. But inasmuch as the input stage gain is variable, the servo stage gain must compensate for it. The operation of the servo stage is identical to the 30 dB/attenuate, but the amplifier gain is a maximum of 20 dB. R31 and R32 are trim resistors if the module gain is not accurate. R13, R14, R15, along with S2, provide a means of changing the gain of the servo output for the two transducer sensitivity ranges.

3.3.10 Calibration

The calibration is initiated by energizing the cal relay, K4. Contacts 5, 6, and 7 switch the cal capacitor in the charge preamplifier to the cal line. Contacts 8, 9, and 10 remove power from the range switch, S1, and turn off FET switch Q2. Contacts 11, 12 and 13 apply power to the -10 dB attenuator line of the input stage, via CR 1, to the -30 dB attenuator line of the 30 dB att/amp, via CR4, and turns on the FET switch Q1. Contacts 14, 15 and 16 short out the transducer sensitivity pot. so that the post amplifier has a precise gain of 10, and 100 mv at the post amplifier input (100 pc at the charge amplifier input) will provide fullscale for all positions of the range switch and transducer sensitivity settings.

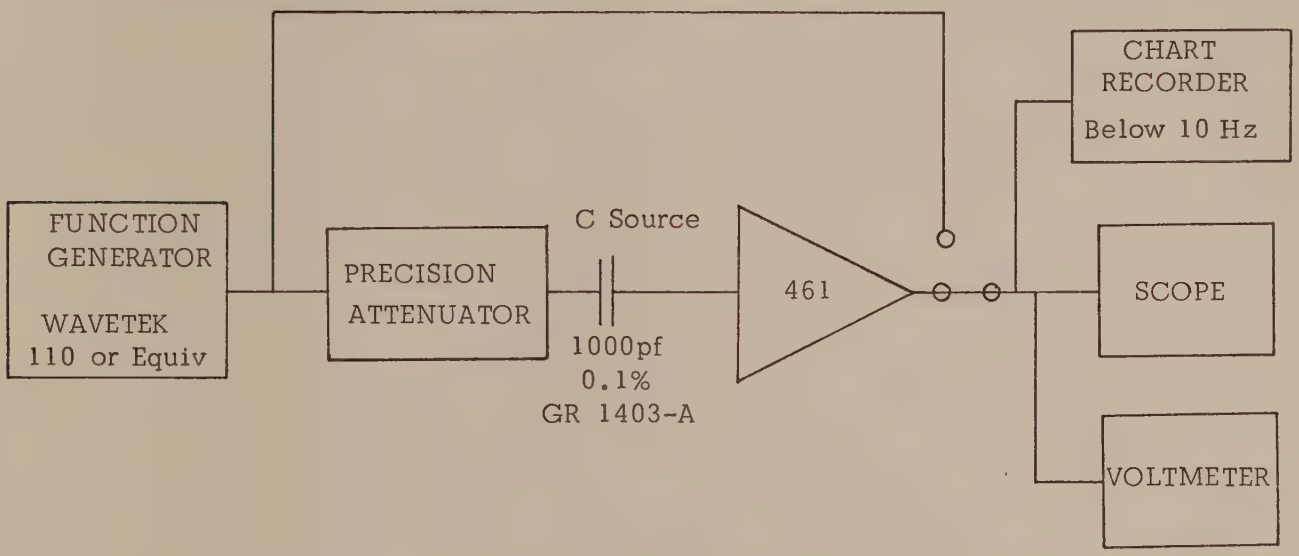
SECTION 4

MAINTENANCE AND CALIBRATION

4.1 INTRODUCTION

There are three adjustments that may be made in the Model 461 Charge Amplifier. It is assumed that the user has chosen the "1 volt peak equals full scale" connection, (see 3.3.5). If not, appropriate corrections must be made for output level.

Although more sophisticated equipment and procedures may be used, the following set up is adequate to calibrate the unit.



A high quality capacitor, such as a GR1403-A Air Capacitor, should be used. The one and two Hz measurements are difficult since standard rms meters do not operate at that frequency. A strip chart recorder is adequate. In any case, the measuring instrument may be switched back and forth between the source and the Model 461 output to cancel any error in the measuring equipment.

4.2 TRANSDUCER SENSITIVITY POTENTIOMETER

The front panel Sensitivity control is a 10 turn potentiometer. It is required that the combination of R11, R12, and R30 equal 1 turn of the Sensitivity control. To accomplish this, set the attenuator to 0 dB, the Range control to 1K/100, and the Sensitivity control to 10.00. Set the generator to 1V rms. The output should increase by exactly 10.0 times when the Sensitivity is adjusted to 1.00 which also should be fully counterclockwise mechanically. If not, adjust R12. Repeat until a ratio of 10.0 is achieved.

4.3 GAIN

With the attenuator still set to 0 dB and with 1V rms input, adjust R29 for 1V rms output. (If full scale is not 1V peak, multiply by appropriate number.)

4.4 OUTPUT OFFSET

With no signal input and Range switch set to 3K/30V adjust the output dc voltage to ±1mV by adjusting R7.

4.5 GENERAL

There are no other adjustments normally required. Performance may be checked by using the above configuration.

SECTION 5

REPLACEABLE PARTS

5.1 INTRODUCTION

This section contains information for ordering replaceable parts. Tables list parts in alphabetical order of their reference designation and indicates the description and manufacturer's part number. When applicable, a typical manufacturer is indicated.

5.2 REFERENCE DESIGNATIONS AND ABBREVIATIONS

Table 5.1 is a list of reference designations and abbreviations.

5.3 CODE LIST OF MANUFACTURERS

Table 5.3 is a Code List of Manufacturers. The manufacturer's code is given with each part. If a code number is missing, the part is a standard designation and available from many manufacturers.

REFERENCE DESIGNATIONS

A	assembly subassembly, separable or repairable
AR	amplifier
AT	attenuator pad termination
B	blower motor synchro
BT	battery
C	capacitor
CB	circuit breaker
CP	adapter, connector coupling (aperture, loop or probe) junction (coaxial or waveguide)
CR	diode rectifier
DS	alarm indicator (excluding meter)
E	antenna arrester, lightning bimetallic strip cell, aluminum or electrolytic contact core, inductor core, memory core, transformer Hall effect device insulator loop antenna magnet, permanent part, miscellaneous electrical post, binding shield, electrical terminal (individual)
F	fuse
FL	filter
G	chopper, electronic generator
H	hardware
HR	heater lamp, infrared
HS	handset
HY	network, hybrid circuit
J	connector, receptacle, electrical disconnecting device jack receptacle (connector, stationary portion)
K	relay
L	coil (all not classified as transformers) inductor
M	clock counter, electrical meter oscillograph oscilloscope recorder, elapsed time register, message strain gage thermometer timer, electric
MK	microphone
MP	frame gyroscope interlock, mechanical mechanical part mounting (not electrical circuit, not a socket) part, miscellaneous mechanical (bearing, coupling, gear, shaft) part, structural reed, vibration tuning fork
MT	transducer transducer, mode
P	connector, plug, electrical disconnecting device (connector, plug) plug, electrical (connector, movable portion)
PS	power supply
Q	transistor
R	potentiometer resistor
RT	lamp, resistance resistor, current regulating resistor, thermal thermistor
RV	resistor, voltage sensitive varistor, symmetrical
S	switch thermostat
T	transformer
TB	strip, terminal terminal board
TC	thermocouple
TP	test point
U	integrated circuit package
V	cell, light-sensitive, photo-emissive electron tube
W	cable cable assembly (with connectors) wire
WT	tiepoint, wiring
X	fuseholder lampholder socket
Y	crystal unit, piezoelectric

ABBREVIATIONS

A	ampere
AC	alternating current
ALUM	aluminum
AMPL	amplifier
ASSY	assembly
BP	bandpass
CAL	calibration
CAR	carbon
CCW	counterclockwise
CER	ceramic
CKT	circuit
COMP	composition
CRT	cathode-ray tube
CW	clockwise
dB	decibel
DC	direct current
DET	detector
DVM	digital voltmeter
ELECT	electrolytic
ENCAP	encapsulated
EXT	external
F	farads
FET	field effect transistor
FREQ	frequency
FXD	fixed
GE	germanium
GL	glass
GND	ground
H	henries
HPF	high-pass filter
HR	hour
Hz	hertz
IF	intermediate frequency
INS	insulation(ed)
INT	internal
K	kilo = 1000
LED	light emitting diode
LIN	linear taper
LOG	logarithmic taper
LPF	low-pass filter
M	Millo 10^{-3}
MEG	meg 10^{6}
METFLM	metal film
MFR	manufacturer
MINAT	miniature
MOM	momentary
MTG	mounting
MYFLM	"mylar" film
N	nano (10^{-3})
N/C	normally closed
NE	neon
N/O	normally open
NPO	negative positive zero
NSR	not separately replaceable
OSC	oscillator
OP	operational
PC	printed circuit
PF	picofarads 10^{12} farads
PIV	peak inverse volt voltage
P/P	part of
PPM	parts per million
POLY	polystyrene
POLYCARB	poly carbonate
POS	position(s)
POT	potentiometer
P-P	peak-to-peak
RC	resistor capacitor network
RECT	rectifier
REF	reference
RF	radio frequency
RMS	root-means-square
S-B	slow-blow
SCR	screw
SE	selenium
SEC	second
SECT	section(s)
SEMICON	semiconductor
SI	silicon
SIL	silver
SL	slide
SOL	solid
SPL	special
TA	tantalum
TGL	toggle
TOL	tolerance
TRIM	trimmer
μ	micro 10^{-6}
V	volt
VAR	variable
VDCW	dc working volts
VCO	voltage controlled oscillator
W/	with
W	watts
WW	wirewound
W/O	without

TABLE 5.1 LIST OF REFERENCE DESIGNATIONS AND ABBREVIATIONS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	CAPACITORS			
C1	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C2	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C7	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C8	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C10	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C11	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C12	330pf, 1000V, 10%, Cer	811572014	48	10TS-T33
C13	330pf, 1000V, 10%, Cer	811572014	48	10TS-T33
C14	.1μF, 200V, 10%, Myflm	811553006	22	W230B1C-104K
C15	.1μF, 200V, 10%, Myflm	811553006	22	W230B1C-104K
C16	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C17	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C18	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C19	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C20	22μF, 15V, Ta	811501103	48	150D226X9015B2
	DIODES			
CR1	IN4148	818100003		IN4148
CR2	IN4148	818100003		IN4148
CR3	IN4148	818100003		IN4148
CR4	IN4148	818100003		IN4148
CR5	IN4005	818100007		IN4005
CR7	IN4005	818100007		IN4005
Q1	Transistor 2 N4302	A86013P3	31	A86013P3
Q2	Transistor 2N4302	A86013P3	31	A86013P3

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	RESISTORS			
	All resistors not otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	10M	817007106		RC07
R2	10M	817007106		RC07
R3	10M	817007106		RC07
R4	10M	817007106		RC07
R5	.68 ohm, 2W, 5%, W.W.	817002003	64	IRC BWH
R6	1M	817007105		RC07
R7	(Pot) 20K	817803203	7	3386P-1-203
R8	10M	817007106		RC07
R9	220K	817007224		RC07
R10	10M	817007106		RC07
R11	147 ohm, *	817210147		RN60D
R12	(Pot) 200 ohm	817803201	7	3386P-1-201
R16	10M	817007106		RC07
R17	10M	817007106		RC07
R18	10M	817007106		RC07
R19	10M	817007106		RC07
R20	470M	817000012	3	CB4772
R21	470M	817000012	3	CB4772
R22	15 ohm	817007150		RC07
R23	2.37K *	817211237		RN60D
R24	1K *	817211100		RN60D
R25	649 ohm *	817210649		RN60D
R26	316 ohm *	817210316		RN60D
R27	147 ohm *	817210147		RN60D
R28	2.37K *	817211237		RN60D
R29	(Pot) 500 ohm	817803501	7	3386P-1-501
R30	215 ohm *	817210215		RN60D

MODEL 461 AMPLIFIER ASSEMBLY C30848G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B21383G1	31	B21383G1
A1-A2	Asm, 1st Stage	B21380G1	31	B21380G1
A1-A3	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A4	Asm, Output	B21789G1	31	B21789G1
A1-A6	Asm, Pwr Isol	B20782G1	31	B20782G1
A1-C9	Capacitor 500pf, 500V, 1%, Sil Mica	811581015	79	DM-19D501F
A1-K1	Relay	814500008	92	CR4DDCA-24VDN
A1-L1	Choke 2.2mH	811800003	10	3387-27
J2	Connector, BNC	812130110	19	30355-1
R1	Resistor (Pot) 1K	817500051	7	35095-8-102
S1	Asm, Switch	B21381G1	31	B21381G1
S2	Switch	A88007P1	31	A88007P1

MODEL 461 OPTION G GALVO DRIVER ASSEMBLY C30853G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR1	Op Amp 709CE	816400016	98	709CE
AR2	Op Amp MC1438R	816400014	35	MC1438R
	CAPACITORS			
C1	.1μF, 50V, 20%, Cer	811570012	25	8121-050-651-104M
C2	.1μF, 50V, 20%, Cer	811570012	25	8121-050-651-104M
C3	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C4	120μF, 10V, 10%, Ta	811501075	48	150D127X9010R2
C5	4.7μF, 10V, 10%, Ta	811501057	48	150D475X9010A2
C6	100pf, 500V, 5%, Sil Mica	811581008	79	DM-15D101J
C7	3pf, 500V, ±.5pf, Sil Mica	811581036	79	DM15C030D
C8	470pf, 1000V, 10%, Cer	811572015	48	10TS-T47
Q1	2N3906 Transistor	818203906		2N3906
	RESISTORS			
R1	22 ohm	817007220		RC07
R2	1.5K	817007152		RC07
R3	1.21K *	817211121		RN60D
R4	10 ohm *	817219100		RN60D
R5	10 ohm *	817219100		RN60D
R6	20 ohm (Pot)	817801005	29	79PR20
R7	15 ohm *	817219150		RN60D
R8	10 ohm *	817219100		RN60D
R9	20 ohm (Pot)	817801005	29	79PR20
R10	1K	817007102		RC07

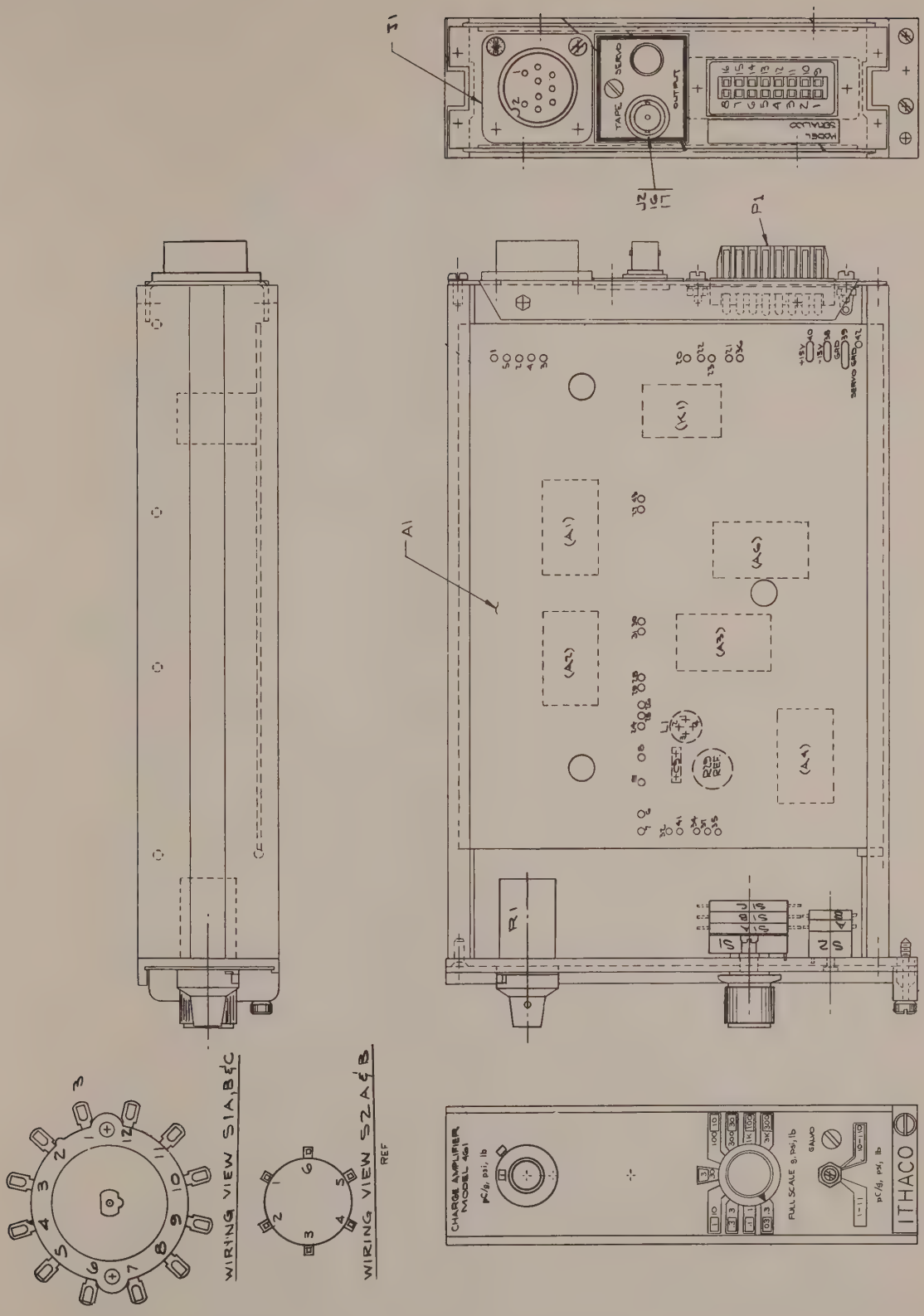
REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	CAPACITORS			
C1	470pf, 1000V, 10%, Cer	811572015	48	10TS-T47
C2	330µf, 6V, 10%, Ta	811501040	48	150D337X9006S2
C3	330µf, 6V, 10%, Ta	811501040	48	150D337X9006S2
C4	Select			
C5	470pf, 1000V, 10%, Cer	811572015	48	10TS-T47
C6	22pf, 1000V, 10%, Cer	811572003	48	10TS-Q22
C7	15µf, 20V, 10%, Ta	811501156	48	150D156X9020B2
C8	.0047µF, 100V, 10%, Myflm	811551033	28	6.1F10AA472
C9	220pf, 1000V, 10%, Cer	811572013	48	10TS-T22
	DIODES			
CR1	IN4148	818100003		IN4148
CR2	IN4148	818100003		IN4148
CR3	IN4148	818100003		IN4148
CR4	IN4148	818100003		IN4148
CR5	IN4148	818100003		IN4148
IC1	I.C. 709CE	816400016	98	709CE
IC2	I.C. 709CE	816400016	98	709CE
	TRANSISTORS			
Q1	TE3906	818203906		TE3906
Q2	TE3906	818203906		TE3906
Q3	TE3906	818203906		TE3906
Q4	2N3904	818203904		2N3904
Q5	2N3904	818203904		2N3904
Q6	Transistor	A86013P3	31	A86013P3
	RESISTORS			
	All resistors not otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
	RESISTORS			
R1	22 ohm	817007220		RC07
R2	5.11K *	817211511		RN60D
R3	100 ohm	817007101		RC07
R4	Select			
R5	3.16K, *	817211316		RN60D
R6	10M	817007106		RC07
R7	14.7K, *	817212147		RN60D
R8	1.47K *	817211147		RN60D
R9	5.11K *	817211511		RN60D
R10	5.62K *	817211562		RN60D
R11	287 ohm *	817210287		RN60D
R12	422 ohm *	817210422		RN60D
R13	5.11K *	817211511		RN60D
R14	5.62K *	817211562		RN60D
R15	1.96K *	817211196		RN60D
R16	19.6K *	817212196		RN60D
R17	Select			
R18	31.6K *	817212316		RN60D
R19	1.47K *	817211147		RN60D
R20	2.49K *	817211249		RN60D
R21	500 ohm (Pot)	817803501	7	3386P-1-501
R22	10K *	817212100		RN60D
R23	31.6K *	817212316		RN60D
R24	31.6K *	817212316		RN60D

CODE LIST OF MANUFACTURERS

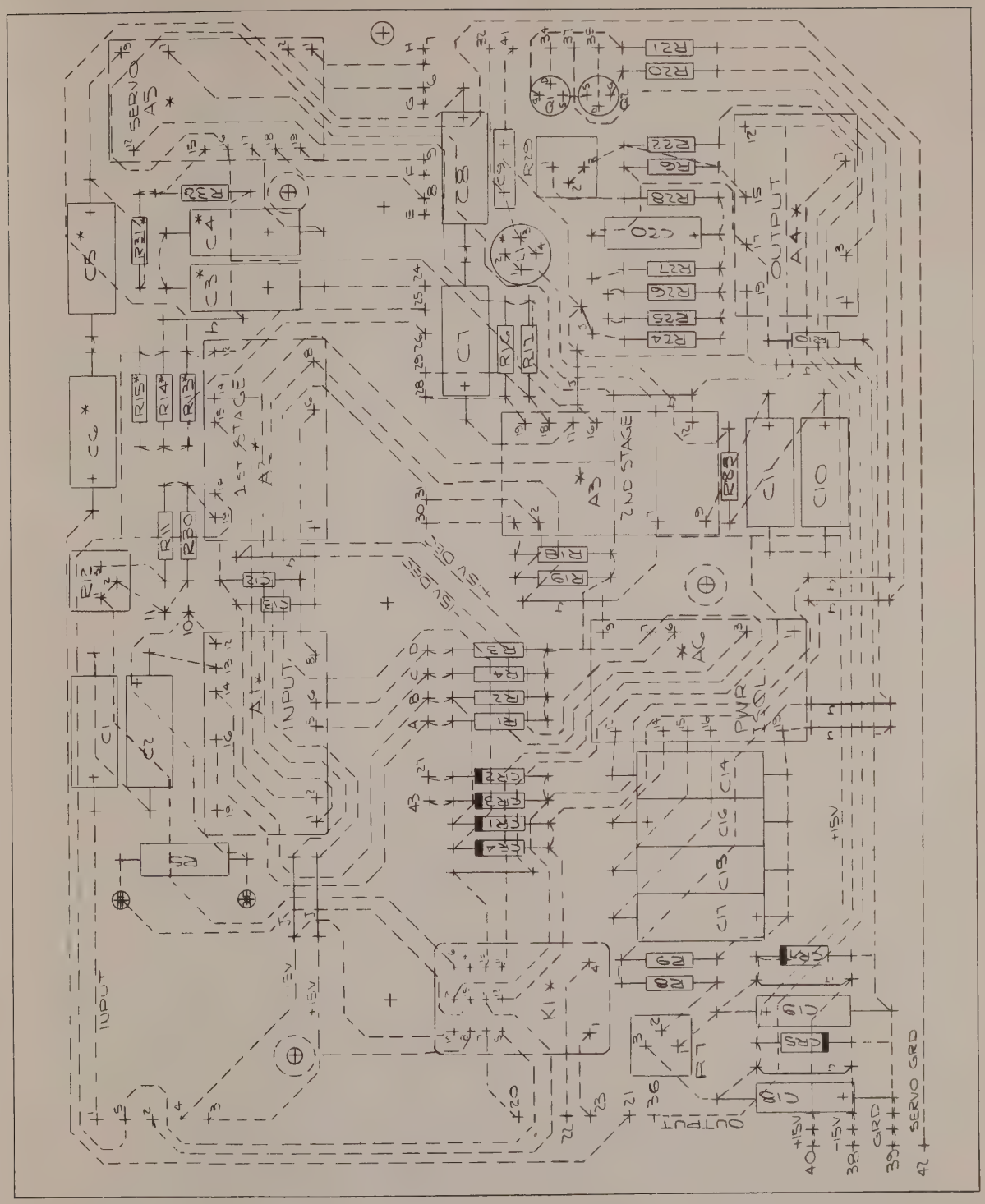
1	Aerovox
2	Alco Electronic Prod
3	Allen Bradley
4	Amphenol Connector
5	Analog Devices
6	Belden
7	Bourns
8	Buckeye Stamping
9	Bussman Mfg
10	Cambion
11	Cannon, ITT
12	Centralab
13	Cinch Mfg
14	C & K Components
15	Continental– Wirt Elec
16	Corcom
17	Cornell Dubilier Elec
18	CTS
19	Dage Electric
20	Delevan Electronics
21	Dresser Systems
22	Electrocube
23	Electro Motive Mfg
24	Electronics Applications
25	Erie Technological Products
26	Fairchield Semiconductor
27	Federal Screw Prod
28	General Electric
29	Helipot
30	Heyman Mfg
31	ITHACO
32	E F Johnson
33	Litronix
34	Marco–Oak Industries
35	Motorola Semiconductor Prod
36	National Semiconductor
37	Ohmite Mfg
38	Paktron
39	Panduit
40	Pomona Electronics
41	Product Components
42	Pyrofilm
43	RCL Electronics
44	Rembrandt
45	Rogan
46	Schauer Mfg
47	H H Smith
48	Sprague Electric
49	Spectrol Electronics
50	Stancor
51	D M Steward Mfg
52	Switchcraft
53	Teledyne Semiconductor
54	Teledyne Western Wire and Cable
55	Texas Instruments
56	Thermalloy
57	TRW
58	United Transformer
59	Useco
60	Vactec
61	Winchester Electronic
62	Vishay
63	ACI
64	IRC
65	EAL
66	AMP
67	Clarostat Mfg
68	Gould Inc
69	Littlefuse Inc
70	General Illumination
71	Signetrics
72	Semiconductor Cir
73	Statek
74	Bendix
75	Burndy
76	American Handle Sales
77	Varo Semiconductor
78	Dialco
79	Elmenco
80	Amp Incorporated
81	Berg
82	Comp Corp
83	Hewlett–Packard
84	Beckman Helipot
85	Raytheon
86	Intersil
87	A H & H
88	ADC Products
89	Scanbe
90	Drake
91	Victoreen
92	Frost
93	Sigma
94	Becon
95	Microswitch
96	Wavetek
97	Electronic Concepts
98	Amelco

TABLE 5.3 CODE LIST OF MANUFACTURERS



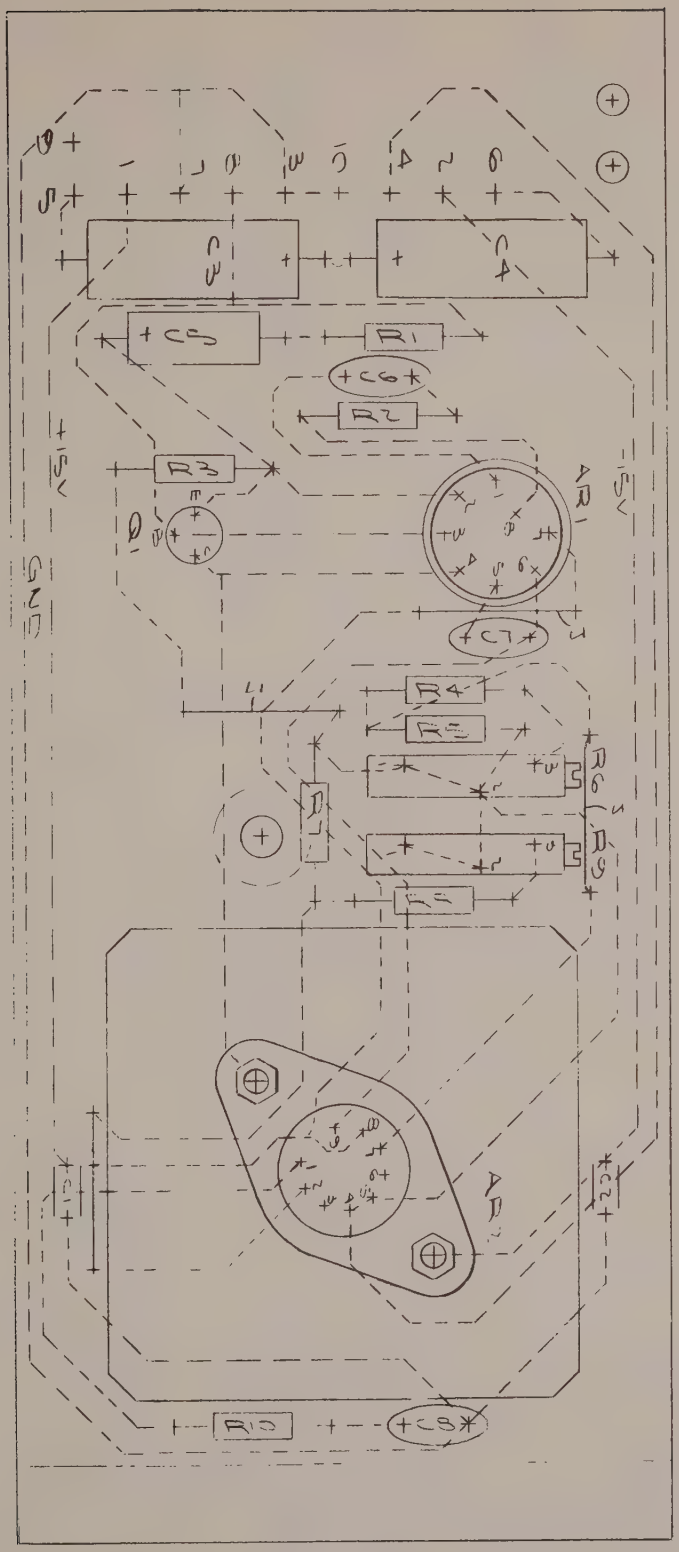
MODEL 461 CHARGE AMPLIFIER
ASSEMBLY

ITHACO DWG NO C30848G1, SH 1, REV E, 8/73



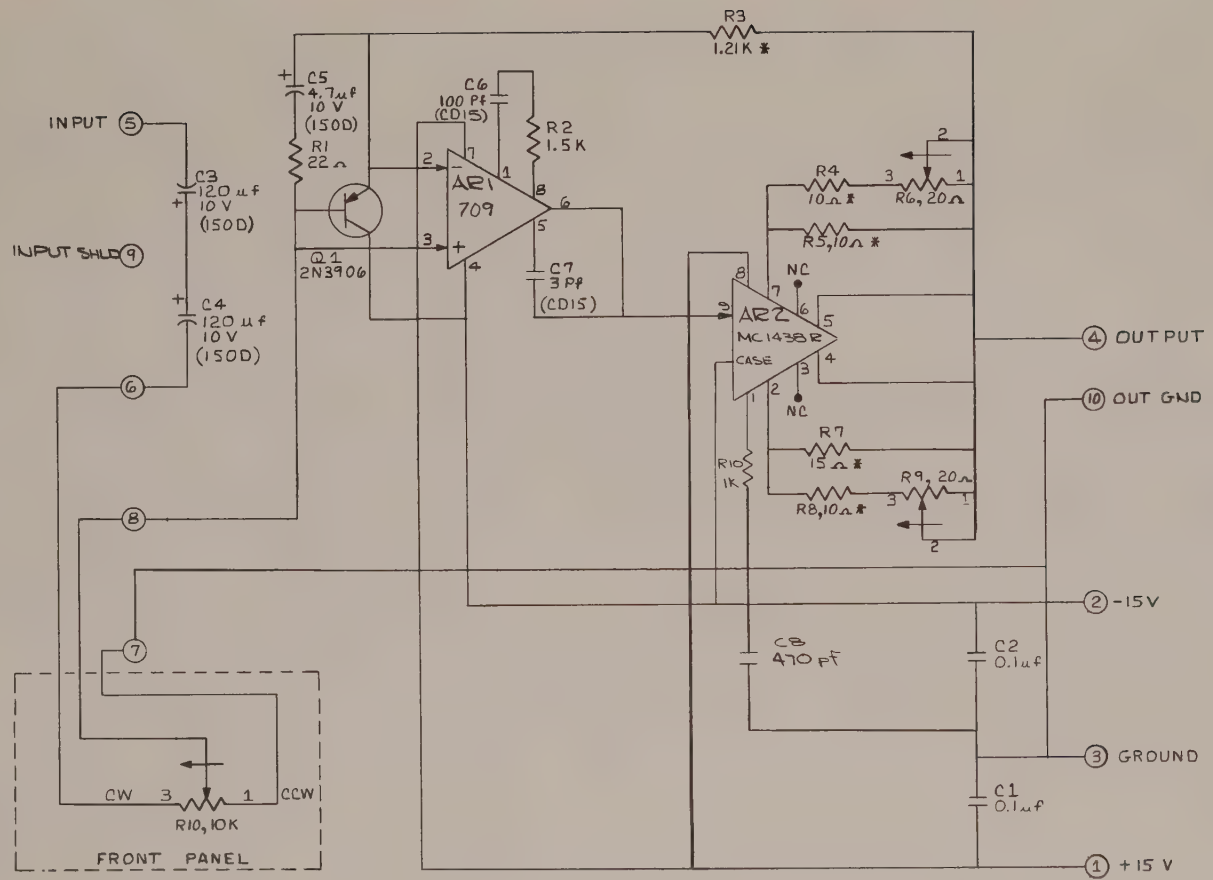
MODEL 461 CHARGE AMPLIFIER
MOTHERBOARD ASSEMBLY

ITHACO DWG NO D40542, SH 1, REV G, 4/77



OPTION G – GALVO DRIVER ASSEMBLY

ITHACO DWG NO C30853G1, SH 1, REV D, 7/77



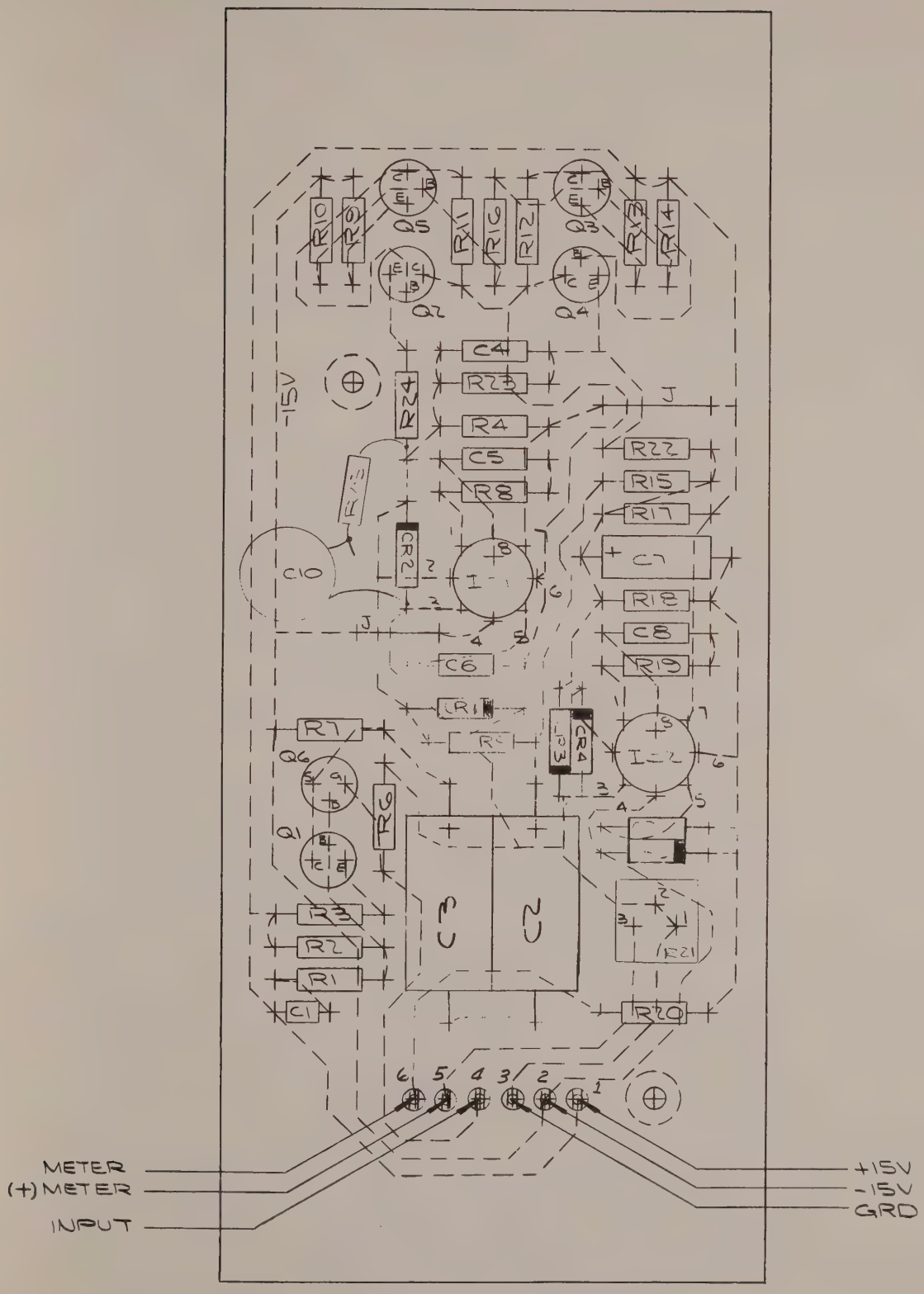
NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, 5%
2. RESISTORS MARKED WITH * ARE 1/8 W 1 %

ITHACO DWG NO C30852, SH 1, REV B, 11/71

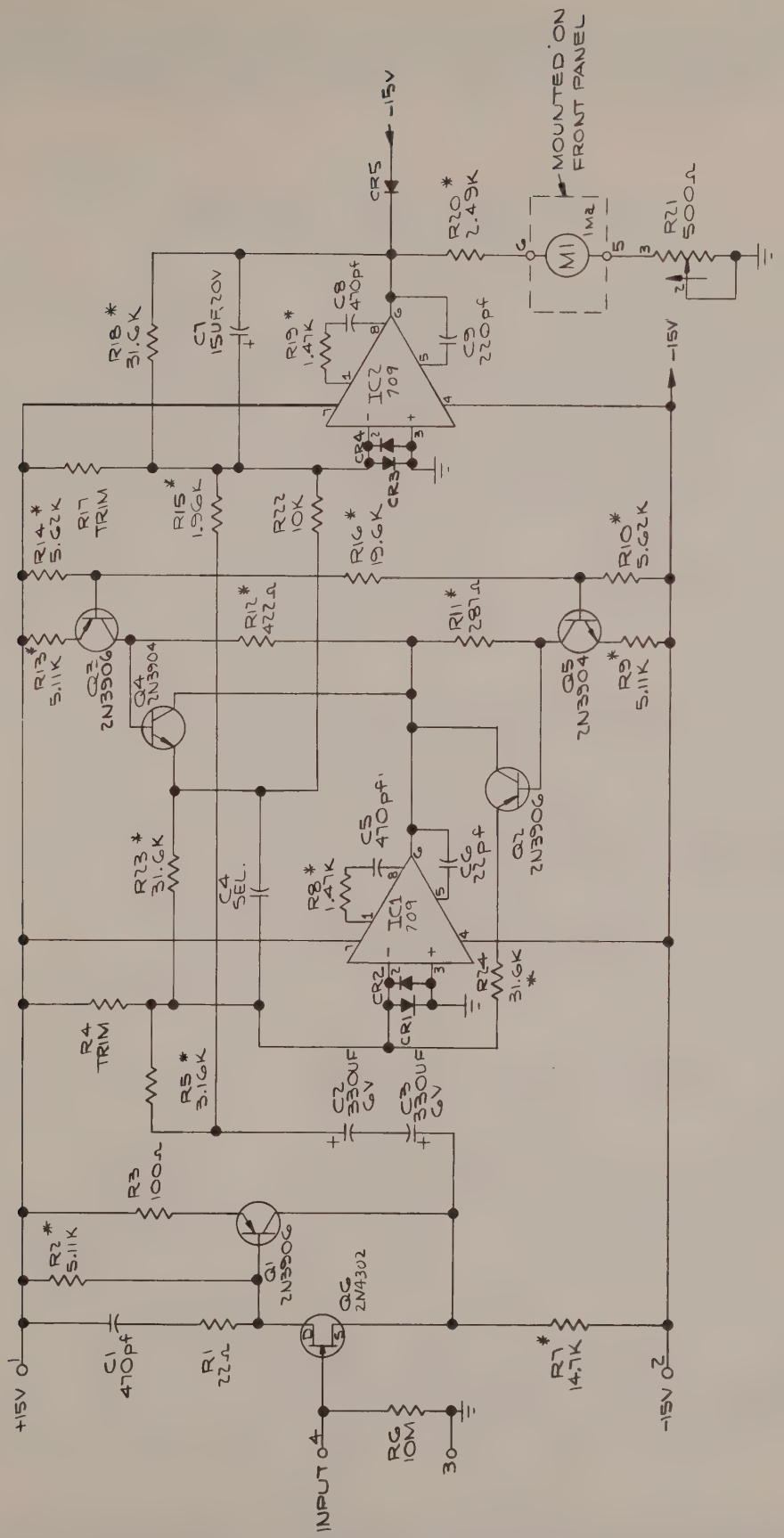
OPTION G – GALVO DRIVER

ELEMENTARY DIAGRAM



ITHACO DWG NO C30816G1, SH 1, REV M, 12/76

OPTION M – METER
CARD ASSEMBLY



ITHACO DWG NO C30815, SH 1, REV F, 4/72

OPTION M – METER
ELEMENTARY DIAGRAM

WARRANTY

ITHACO Inc. warrants each instrument to be free of defects in material and workmanship for a period of one year after shipment to the original purchaser; batteries are specifically excluded. Liability under this warranty is limited to repairing or adjusting any instrument returned to the factory for that purpose. The warranty of this instrument is void if the instrument has been modified other than in accordance with written instructions from ITHACO, or if defect or failure is judged by ITHACO to be caused by abnormal conditions of operation, storage or transportation.

This warranty is subject to verification by ITHACO, that a defect or failure exists, and to compliance by the original purchaser with the following instructions:

1. Before returning the instrument, notify ITHACO with full details of the problem; include model number and serial number of the instrument involved.

2. After receiving the above information, ITHACO will give you shipping instructions or service instructions. After receipt of shipping instructions, ship the instrument to ITHACO. Full liability for damage during shipment is borne by the purchaser. It is recommended that instruments shipped to us be fully insured and packed surrounded by at least 2 inches of shock-absorbing material.

ITHACO reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of ITHACO, and ITHACO neither assumes, nor authorizes any other person to assume for it, any liability in connection with the sales of ITHACO instruments.

ITHACO INC.
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